

High Voltage Distribution for RPCs

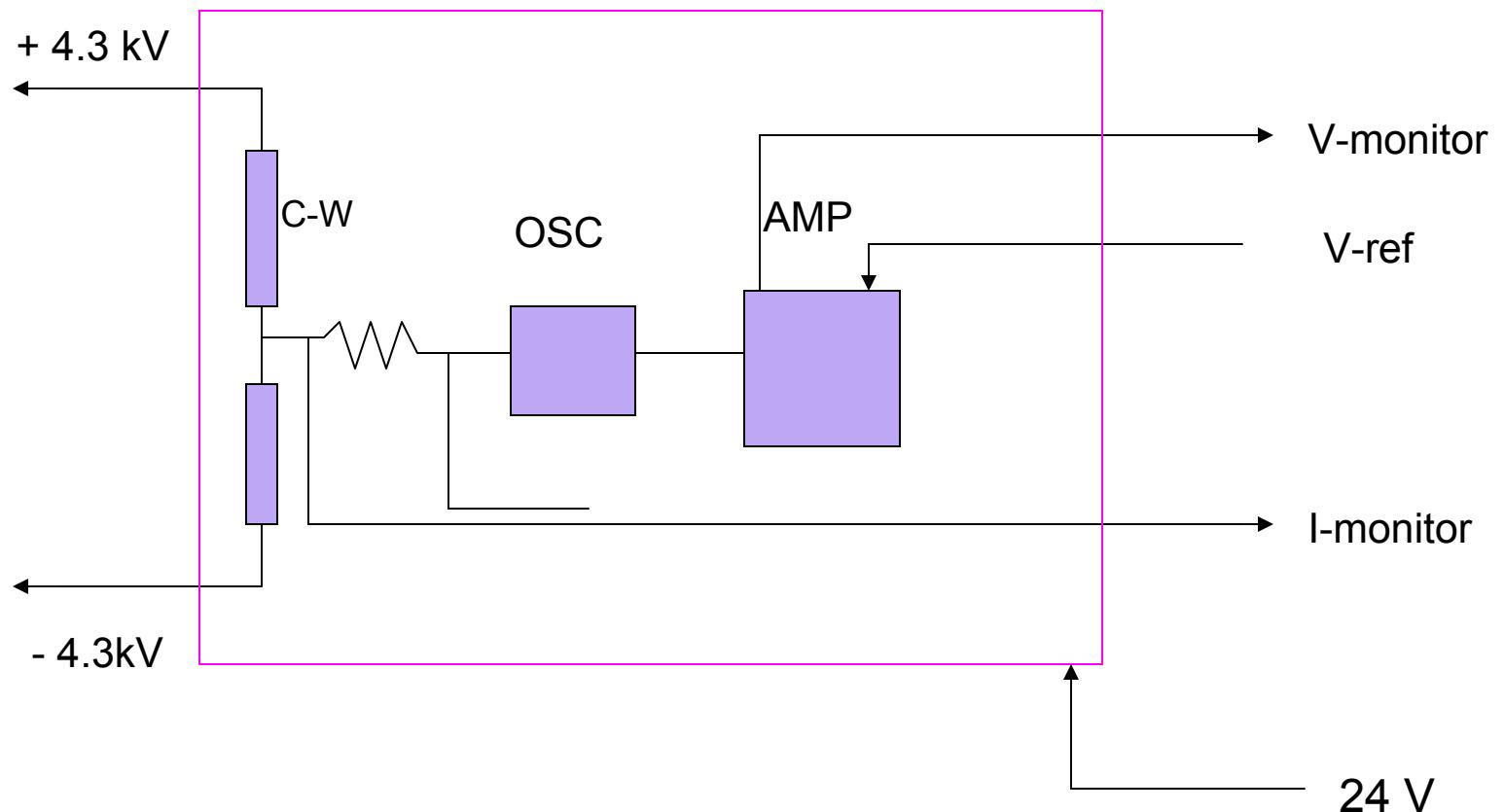
- Cockcroft-Walton HV System
 - Motivation
 - Prototype tests
 - Description of System
 - Cost
- “Conventional” HV System
 - Description
 - Cost
- Summary

www.hep.anl.gov/rilt/Off_Axis/RPC_HVApril2603.ppt

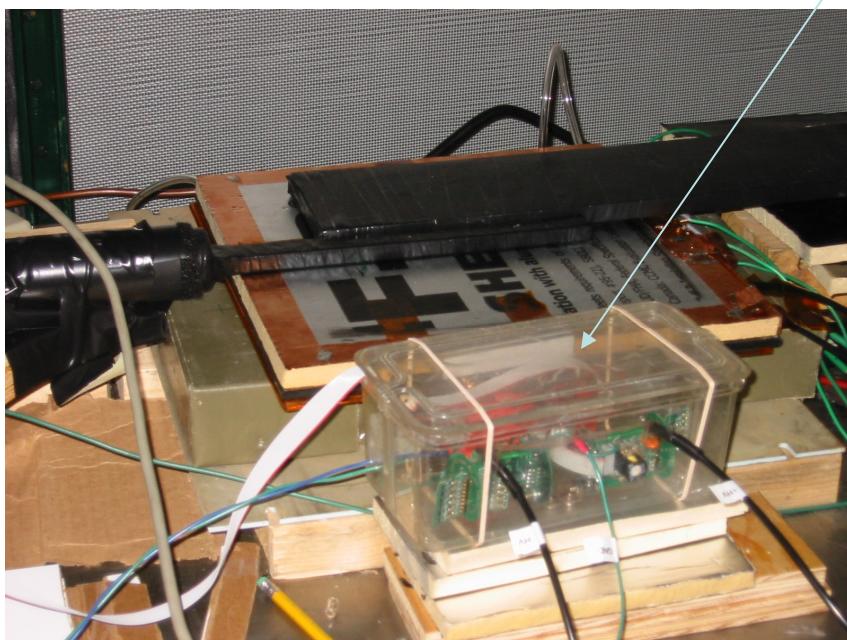
Cockroft-Walton HV Supplies

- Individual Voltage Control for Each RPC
 - Individual current monitors
- Competitive Cost
 - About the same as least expensive “conventional” HV
- Safety: No access to HV outside the detector
 - Low voltage on all external cables
 - 24 V to power the system
 - reference and readback signals (few Volts)
 - C-W is integrated with particle board structure
 - very close to the RPC
 - no HV connectors (wire soldered to RPC & to C-W)

Block Diagram of a C-W Supply



Prototype 8.6 kV (+/- 4.3kV) Cockcroft-Walton Connected to an RPC

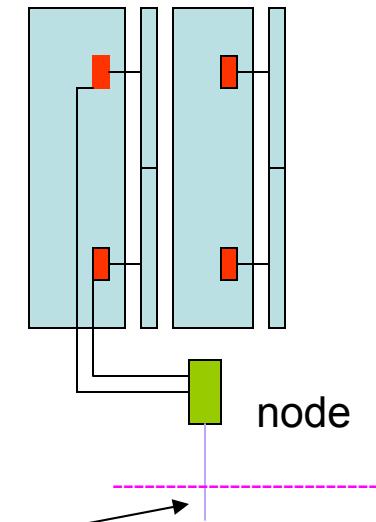


In use with RPC at FNAL

- RPC with 1mm and 2mm gaps
 - Operated at 5.8kV and 8.2kV
 - No noise detected
- Prototype based on ZEUS c-w
 - Same pc cards
 - 21 instead of 17 capacitors
 - 500V caps, nominally @200V
 - No current readback implemented
- Next: New C-W pc card design
 - Specific to Off Axis expt.
 - Operate in cosmic ray RPC detector @FNAL

C-W System for One Container

- 24 C-W units, attached to top of absorber
- Controlled by CANbus* node
 - multiplexed DAC to set individual HV
 - multiplexed ADC to read back voltage & current
- Connections to the outside
 - » 2 cables: serial data & 24V @1.25A



*

CANbus standard developed for automobile industry

- robust & dependable; used on ATLAS for slow control

C-W System: Full Detector

- **2,000 containers**
 - Serial data (slow control)
 - 2,000 nodes → 8 CANbus serial ports @250 nodes/port
 - 2 serial ports per NI PCI-CAN/2 card → 4 cards in a PC
- **Power: 60 kW**
 - 30 W per container: 24 W for RPCs, 6 W for node
 - Allow for ~30% safety margin
 - ~ 80 1kW supplies, for example

C-W Cost for each Container is \$2K

- **C-W supply**
 - parts, assembly & test \$45
 - installation (20 min@\$50/hr) \$17
 - 24 per container \$1,488
- **CANbus node** \$100
- **10-conductor cable** 400 ft @\$0.11/ft \$44
- **Cable & node connectors**
 - parts \$100
 - labor 4 hrs @\$50/hr \$200
- **TOTAL per container** \$1,932

C-W Cost for Entire Detector is \$4M

• 2,000 Containers @ \$1,932 each	\$3,864,000
• 2-conductor cable (24V)	\$12,800
– 160,000ft	
• Shielded serial cable	\$28,000
– 160,000ft	
• 80 1kW 24V supplies	\$48,000
• TOTAL Detector	\$3,952,800

- Note: Not Included...but not significant
 - 4 NI PCI-CAN/2 cards and PC
 - Container patch panel connectors

Conventional HV

current-per-channel sets cost scale

“Simple and least expensive, yet reasonable system”

- **One HV channel serves 48 RPCs**
 - Operating Voltage: ~ 8 kV for ~2mm gap
 - $1\mu\text{A}/\text{m}^2$ dark current (BELLE result...mostly through spacers)
 - up to ~ $5\mu\text{A}/\text{m}^2$ if there are problems ... (HV drop limits the current)
 - 173 m^2 of RPC area per container
 - ~ $173 \mu\text{A}$ per container with properly-operating RPCs
 - Typical commercial HV channel provides ~1mA @10kV
 - 2 containers per HV channel → ~ $350 \mu\text{A}$ is reasonably safe load
 - **HV System:** **1000 HV channels for entire detector**

1HV channel → 1 current measurement for 48 RPCs
→ 1 HV setting for 48 RPCs

Container Detector: Conventional HV Cost

- HV System: CAEN SY1527 **\$1,082k**
 - Module A1526: 6 HV ch @ 1mA/15kV per ch
 - 167 modules → 1002 channels \$835k
 - Crate SY1527: fits 8 Modules A1526
 - 21 crates @8 modules/crate \$247k
- RG58 cable, connectors (attached) **\$2,598k**
 - 400 ft./container interior
 - 80 ft from HV supply→ container
 - 50,000 10kV connector pairs @ \$23.50/pair
 - 2, 000 HV distribution panels
- Total HV cost **\$3.7M**
- Note: Cost estimate for Monolithic Detector: **\$3.8M**

+HV to anode and – HV to cathode?

- **Advantages** (as in the BELLE experiment)
 - “Reduces the potential to ground on connectors, cables and surfaces as a precaution against external discharges through and around insulators”
 - “Helps reduce the overall HV system cost since modules capable of producing voltages in excess of 7.5 kV are less common and therefore more costly”
- Saves on HV supply costs but doubles the number of HV connectors, distribution boxes and cables
→Higher cost

Summary

- C-W System advantages over Conventional HV System
 - Safety: no external HV (8kV @ 1mA)
 - Less likelihood of corona discharge (no connectors, $\frac{1}{2}$ voltage)
 - **Individual control and read back for each RPC**
- C-W prototype operated RPC @ 5.8 and 8.2 kV successfully
- Conventional HV System
 - Prohibitively expensive with 1 channel/RPC
 - With 48 RPC/channel
 - Largest cost due to HV connectors
 - Cost for +/- HV capability is significantly higher
- Future plans
 - New C-W supplies for cosmic ray module
 - Current readback
 - CANbus control